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Waquoit Bay Research Report 1992-1993

Waquoit Bay National Estuarine Research Reserve Science and Policy Bulletin Series

The Waquoit Bay National Estuarine Research Reserve (WBNERR) is one of 21 reserves in the National Estuarine Research Reserve System (NERRS). The primary function of the reserves is to serve as natural laboratories for research that fosters our understanding of estuarine ecosystems and to apply this research to coastal management issues. WBNERR is administered by the National Oceanic and Atmospheric Administration (NOAA) and the Massachusetts Department of Environmental Management (DEM).

As part of the national reserve system, research at WBNERR follows the general priorities of NERRS, which for 1992-93 focus on the effects of non-point sources of pollution (NPSP). Other research and monitoring activities augment the scope of estuarine science at the Reserve.

Land Margin Ecosystem Research Project

WBNERR is unique within NERRS because it is a study site for a Land Margin Ecosystem Research (LMER) Project, which is jointly funded by NOAA, the National Science Foundation (NSF) and the Environmental Protection Agency (EPA). The Waquoit Bay LMER (WBLMER) also supports research that aims to increase understanding of the impact of NPSP on estuaries.

The multidisciplinary project, one of five LMER studies in the continental U.S., is directed by Dr. I. Valiela of the Marine Biological Laboratory (MBL) and the Boston University Marine Program (BUMP). WBNERR's association with the LMER project brings a large amount of intensive research to the Reserve which will greatly accelerate our understanding of how the Waquoit Bay ecosystem functions and responds to perturbations. The Reserve contributes by serving as a research and logistic support facility, and perhaps of greater importance, as an interface between WBLMER scientists and the policy makers who are responsible for determining the course of development within the region.

Much of the WBLMER research is based on the premise that land use in Waquoit Bay's watershed (the land area draining into the bay and its tributaries) affects the ecosystems near and within the bay. WBLMER research takes advantage of the fact that there are subwatersheds within the Waquoit Bay drainage basin (Fig. 1).

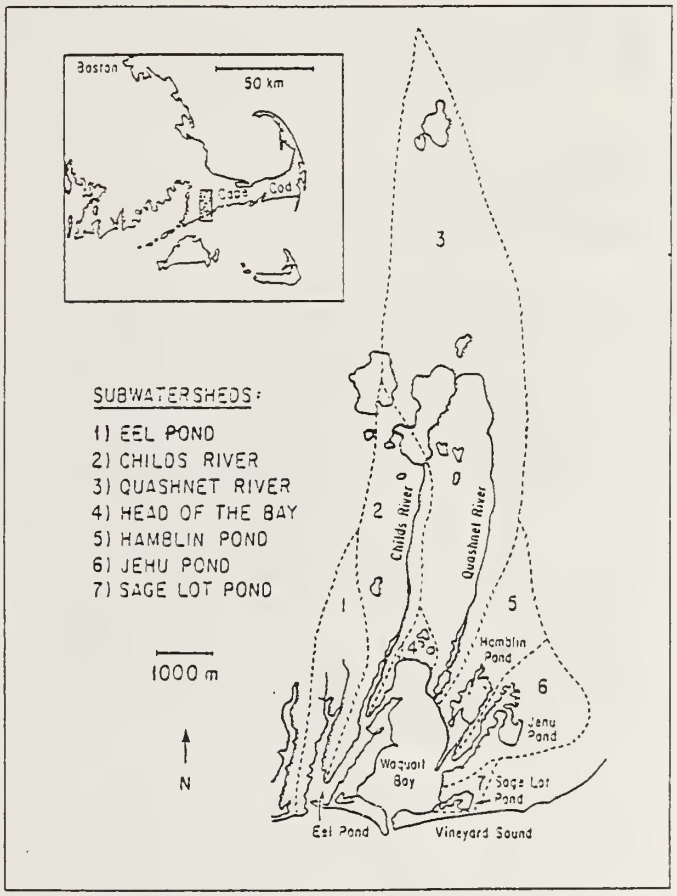

Figure 1. The watershed and subwatersheds of Waquoit Bay (WBLMER).

These subwatersheds have experienced different rates of development (Fig. 2). As a result, the subwatershed that drains to the Childs River is highly developed, the one that drains to the Quashnet River is moderately developed, and the one that drains to Sage Lot Pond is relatively pristine.

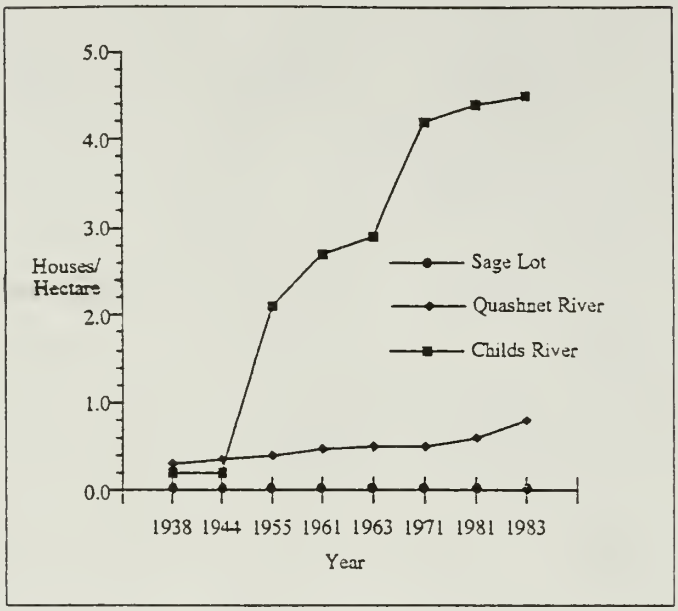

Figure 2. Housing density over time in the three subwatersheds of Waquoit Bay (WBLMER).

Nitrogen Loading and Eutrophication

Residential and commercial development increases the amount of nitrogen in an ecosystem. Adding nitrogen to an estuary typically leads to increased growth of seaweeds and phytoplankton, which can, in turn, affect the concentration of dissolved oxygen in the water. These events can lead to eutrophication, the addition of excess nutrients resulting in overgrowth of some plants at the expense of other species.

In Waquoit Bay, high nitrogen inputs are correlated with reduced growth rates and decreased survival of eelgrass (*Zostera marina)* beds, an important habitat for finfish and shellfish. Thus, nitrogen inputs have a strong influence, directly and indirectly, on many facets of estuarine structure that concern natural resource planners and managers.

Although scientists agree on the general principles of "nitrogen loading" and eutrophication, they do not yet know the answer to such questions as: "How much nitrogen can we add to an estuary before we exceed its capacity to assimilate it?" or "How can we decrease the amount of nitrogen coming to the bay from existing developments: install nitrogen-removing septic systems, reduce the size of lawns, or plant more trees in the watershed?"

To address these questions WBLMER researchers study the nitrogen cycle in the Waquoit Bay watershed to learn how much nitrogen enters from different sources, where it goes, how much is removed at different stages, how fast it travels, and how rapidly different algae respond to various amounts of nitrogen. WBNERR channels this information to local, regional, and state officials to better manage coastal watersheds and protect their resources.

How Does Nitrogen Enter the Bay?

The primary sources of nitrogen to the bay are acid rain, wastewater from septic tanks, and fertilizers. Estimates from 1992 suggest that septic tanks furnish almost 40% of the nitrogen entering the bay (Table 1). Although these values will probably change as researchers refine their understanding of the nitrogen budget, data indicate that septic leachate has a potent influence on the bay.

Table 1. 1992 estimates of the percentage of total nitrogen entering Waquoit Bay from various sources. Data from WBLMER.

Source of Nitrogen	% of Total Nitrogen
Precipitation	
onto land surfaces in watershed	50
directly onto bay	5
Septic Tanks	38
Fertilizer	7

Because housing and related activities contribute so much nitrogen to the groundwater, we expect higher nitrogen concentrations in the groundwater of heavily developed watersheds such as the Childs River than in groundwater of relatively undeveloped watersheds such as Sage Lot Pond. Measurements of nitrogen concentrations in groundwater by M. LaMontagne and Dr. I. Valiela support these expectations (Table 2).

Investigation has found that nitrogen concentrations in Waquoit Bay are much lower than in the rivers flowing into it. However, even the highest freshwater nitrogen concentrations (0.7 milligrams per liter in the Childs River) are considerably lower than the highest concentrations found in groundwater nearby (10.5 milligrams per liter).

This discrepancy suggests that denitrification (the conversion of nitrate to nitrogen gas) may occur at the boundary where the groundwater and surface water meet, a topic of a new WBLMER study.

Table 2. Nitrogen levels in groundwater of the Childs River subwatershed compared to that of Sage Lot Pond.

	Nitrate Concentration in µM	
	Childs River	Sage Lot Pond
Maximum	736.38	29.24
Average	440.85	13.15
Minimum	162.81	2.60

Ecosystem Responses to Nitrogen Loading

The growth rates of seaweeds also reflect the pattern of nitrogen inputs to the subestuaries of Waquoit Bay. Research by Dr. P. Peckol and B. DeMeo-Anderson indicates that algae in the Childs River grow faster during long summer days than those in Sage Lot Pond (Fig. 3); phytoplankton, microscopic plants that live in the water column, respond similarly (Dr. K. Foreman, Fig. 4).

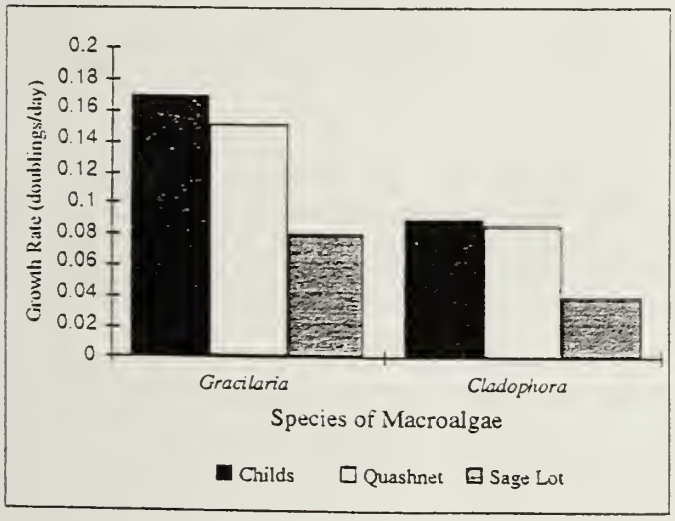

Figure 3. Growth rates of seaweeds in three subestuaries. Typically macroalgal growth rates are reported as doublings per day, defined as the percentage of the change required to double the biomass in one day. A rate of 0.2 means the mass increases 20% in one day. Data from Dr. P. Peckol (Smith College and WBLMER).

WBLMER researcher D. Hersh has found that the greatest biomass of seaweed is found in subestuaries with the highest nitrogen concentrations. However, seaweed biomass does not vary seasonally as expected. Furthermore, the amount of seaweed biomass actually found in the bay is significantly less than predicted. Some of the biomass may be lost by burial and decomposition in the sediment; still more may be swept out of the bay by tides. Another portion may be consumed by various grazers (e.g., grass shrimp and amphipods).

Dissolved Oxygen

The amount of dissolved oxygen in water fluctuates in response to biological (e.g., photosynthesis and respiration) and physical (e.g., temperature and wind-mixing) events. Finfish and shellfish inhabiting Waquoit Bay have adapted to these natural fluctuations. However, excess plants cause extreme fluctuations that may stress all of the bay's inhabitants. During the day, seaweeds produce oxygen as they photosynthesize. But at night, they consume oxygen as they respire, lowering the dissolved oxygen concentration.

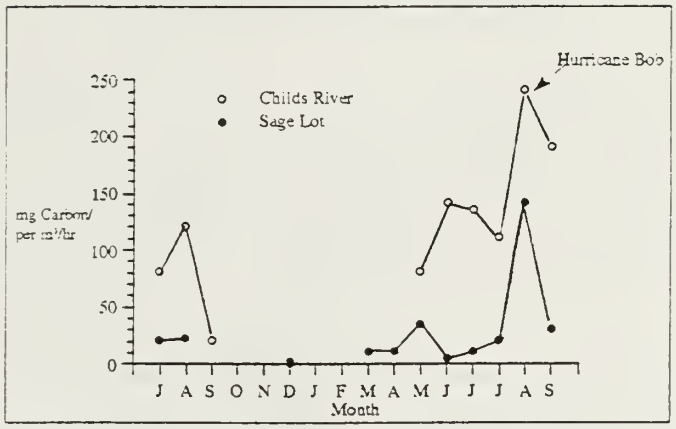

Figure. 4. Production of phytoplankton in 2 subestuaries. Data from K. Foreman (BUMP and WBLMER).

Weather conditions can exaggerate these daily fluctuations. Periods of bright sunshine (which maximizes photosynthesis) and brisk winds (which maximize diffusion of atmospheric oxygen into the water) increase dissolved oxygen levels. On foggy windless days, decreased photosynthesis and wind mixing may result in insufficient oxygen for respiration by the plants and animals. If this condition persists, the bottom waters may be depleted of oxygen and many fish and invertebrates die (Fig. 5).

Drs. C. D'Avanzo and J. Kremer examined these fluctuations with automated sampling devices that record dissolved oxygen levels at 15 minute intervals for one week. Data show clearly that the changes between late afternoon and early morning oxygen concentrations are especially apparent for waters nearer the bottom (depth about 1 meter), where the contribution of atmospheric diffusion is diminished (Fig. 6).

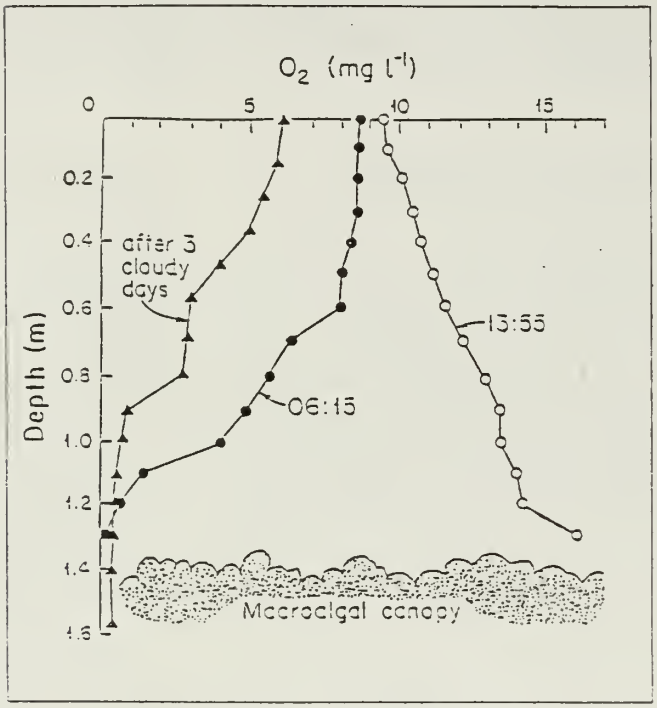

Figure 5. Oxygen levels in the water column in the early morning hours following a series of cloudy, still days in July, 1990. Data from Dr. C. D'Avanzo (Hampshire College and WBLMER).

Within the algal mat, nutrients and oxygen levels reflect the amount of light penetrating the mat. Oxygen concentrations are higher at the surface of the mat and decline rapidly deeper in the canopy, according to Dr. C. D'Avanzo. The shaded lower levels beneath the canopy receive insufficient light for photosynthesis and waters there are hypoxic (low in oxygen). Here, organisms die and decay releasing ammonium ($NH4^+$) into the water where it is available for new plant growth. Levels of $NH4^+$ are highest near the bottom and decrease upward through the canopy, possibly due to $NH4^+$ uptake by the photosynthesizing, growing, upper half of the canopy (Fig. 7).

Algae from the deeper, shaded portion of the canopy can be healthy and show no sign of stress. Water movements may disturb the mat, exposing previously shaded plants to sunlight (so-called "turn over"). Because algal mats cover most of the bottom of Waquoit Bay, hydrographers need to understand how the presence of the mat influences the movement of water masses flowing over it. WBLMER scientists Drs. P. Peckol and D. Aubrey are addressing these questions by studying water flows over an algal mat in a flume tank at the Coastal Research Center at WHOI.

Flushing Rates and Eutrophication

The residence time of water within the estuary (also called the flushing rate) affects nutrient dynamics. Because nitrogen enters the bay in freshwater, it is important to know where and to what degree freshwater mixes with the saltwater that enters the bay from Vineyard Sound. Also, nitrogen may be flushed out of the bay, depending upon the rates and patterns of tidal exchange.

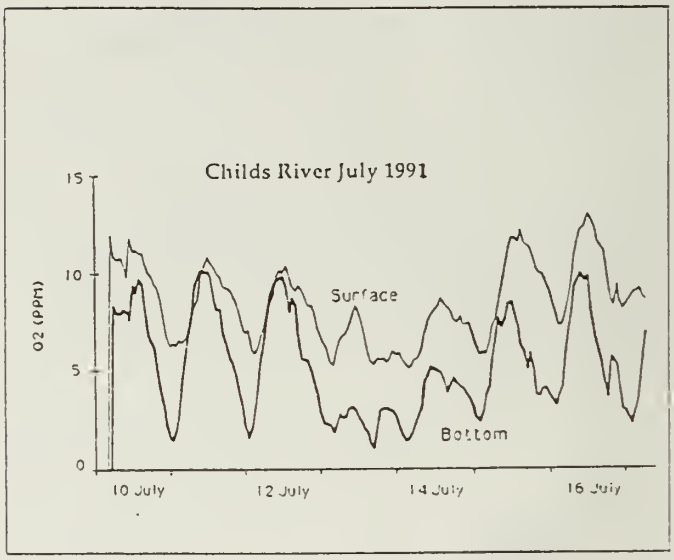

Figure 6. Changes in concentration of dissolved oxygen in surface (lighter line) and bottom water (darker line) between July 10 and July 14, 1991. Data from Dr. C. D'Avanzo (Hampshire College and WBNERR) and Dr. J. Kremer (Univ. Southern California and WBNERR).

Researchers at WHOI, Dr. D. Aubrey and T. McSherry, have developed a one-dimensional numerical model to describe the patterns of water movement in Waquoit Bay and its subestuaries. Because freshwater is often stratified on top of saltwater, and because the biological components of the ecosystem are often segregated between these layers, these hydrographers are developing a more sophisticated two-dimensional model, which will describe how the water moves in a vertical direction as well as in a horizontal direction.

Groundwater

Just as knowledge of water movement in the bay is important to the study of nutrient loading, so is understanding the flow of groundwater in the watershed. Cooperating closely with the WBLMER researchers are scientists at the Cape Cod Commission's (CCC) Water Resources Office. There Dr. T. Cambareri, Dr. E. Eichner, and C. Griffeth are examining several important facets of groundwater flow under an EPA grant. First, through an extensive measurement of water table levels in hundreds of wells, they have refined the water table map and updated the boundaries of the Waquoit Bay watershed and subwatersheds. Second, they have drilled wells in the bay to determine how groundwater and surface water interact. Third, they have characterized the subsurface geology of the watershed.

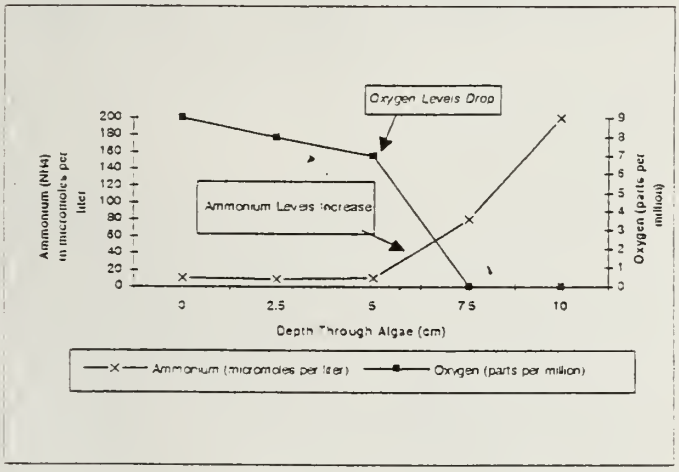

Figure 7. Proceeding from the surface to the bottom of an algal mat, oxygen levels decrease and ammonium levels increase. Data from Dr. C. D'Avanzo (Hampshire College and WBLMER).

In addition, the CCC's Geographic Information Systems (GIS) Office has digitized information about land use in the Waquoit Bay watershed and has created maps from it. The commission is reviewing and updating the inventory of land use within the watershed so that new and up-to-date maps will be available to the researchers.

WBLMER scientists, Dr. Chi Sham and J. Brawley, are using this new information from the CCC to study related questions about groundwater using complex computer simulations and calculations. They are modelling how fast and in which direction groundwater moves within each subwatershed and comparing their results with CCC field measurements and other data. With these "calibrated" models, they have developed estimates of the rates of nitrogen loading, as well as the travel time for nitrogen passing through the watershed and into Waquoit Bay, based on past, present, and predicted future land use patterns.

A simplified version of this model[1] is being developed by Dr. J. Kremer and G. Collins for community planning boards and other agencies. As with all of the WBLMER models of groundwater dynamics in the watershed, the model assumes that knowing the watershed boundaries, land use patterns, and groundwater flow patterns will improve estimates of the amount of nitrogen reaching the bay at a given time. As part of an EPA study, the model is also being evaluated by planners in several Cape towns and elsewhere to explore its applicability beyond the Waquoit Bay watershed. For this aspect of the work, WBNERR acts as liaison between the scientists and user groups and is responsible for training and maintaining the exchange of information between all parties.

Terrestrial Ecosystem Studies

As noted above, a major source of nitrogen entering Waquoit Bay is thought to be from precipitation falling on its watershed (Table 1). This differs from the traditional thought that precipitation-borne nitrogen is effectively sequestered as organically-bound nitrogen in forest biomass and in soils. The belief that there is a significant passage of precipitation-borne nitrogen through the forests of the Waquoit Bay watershed, into the groundwater, and eventually into the bay results from WBLMER research of the terrestrial ecosystem.

Dr. K. Lajtha and B. Seely have determined that on an annual basis only about two-thirds of the nitrogen delivered to watershed surfaces by precipitation is retained by the forested coastal ecosystem. A significant (albeit as yet undetermined) portion of the remainder enters the groundwater, primarily during winter. However, because not all of this is dissolved inorganic nitrogen, the form most readily utilized by plants, only some of the mobile fraction passing through the soil stimulates algae growth in Waquoit Bay. Research is continuing to refine our understanding of the nitrogen budget in the Waquoit Bay watershed.

[1]For a further discussion of computer models, see WBNERR Science and Policy Bulletin #1: "What Are Computer Models and What Can They Tell Us About Waquoit Bay?

WBNERR Research Projects

WBNERR conducts its own suite of research programs in addition to other research projects and programs at the Reserve. In 1992 some projects augmented the NPSP studies of the WBLMER; other activities ventured into different areas and broadened the range of investigations at the Reserve. Some of the latter contained significant resource management content but are included because of their contribution to the WBNERR science programs.

WBNERR Research Coordinator Program

In July 1992, Dr. R. Crawford was hired as the WBNERR Research Coordinator. His responsibilities include developing a comprehensive research program at the Reserve. As he became familiar with the Reserve facilities, resources and its territory, he also became an active participant in several ongoing projects (e.g., studies of barrier beach hurricane damage and the impacts of docks) and designed a study of the early life history of fishes in Waquoit Bay, scheduled to begin in 1993.

GIS Study of Waquoit Bay Nitrogen Loading from Land Use Patterns

P. Sloan of the Association for the Preservation of Cape Cod (APCC) in collaboration with N. Gurwick of WBNERR used the WBNERR Geographic Information System (GIS) facilities to develop maps to derive nitrogen loading estimates from land use patterns. Land use information was derived from the McConnell data base (provided by the Cape Cod Commission). Parameters describing loading factors for various land uses were based on those developed by the Buzzards Bay Project. These GIS maps will help town officials understand how different zoning scenarios and land use practices affect the ecosystem.

A similar but more complex mapping effort is underway within the WBLMER. WBNERR is coordinating ongoing dialog between the two groups and facilitated an evaluation of the APCC work by WBLMER scientists and the EPA. Comparisons of the results of the two efforts will provide valuable insight into the level of precision required in the study of nutrient enrichment.

Phased Monitoring Program

An important element of NERRS is its Phased Monitoring Program. This program consists of a research component (done by researchers outside NEERS), a monitoring component (done by NEERS staff), and a descriptive component (Site Profile development). Phase I consists of environmental characterizations involving literature and field research. Phase II is the synthesis of this information into a Site Profile Document. Phase III consists of the long-term monitoring of resources and variables identified as "key" components of the ecosystem at each Reserve. At WBNERR, the long history of research provides a solid foundation for environmental characterizations (Phase I). This data base is expanding due to the efforts of WBLMER researchers. In 1992, the WBNERR Phased Monitoring Program entered Phase II with the initiation of a project to write the WBNERR Site Profile. Also that year, the program came under the direction of the Research Coordinator who began an environmental variable monitoring project which will be part of Phase III. Recent activities in the program are described below.

WBNERR Site Profile

WBNERR has a complex estuarine ecosystem comprising uplands, freshwater and tidal wetlands, rivers, estuaries, barrier beaches, islands and tidal flats. Many of these systems have been affected by human activities and natural events. Because of these complexities, designing an effective resource monitoring program requires a thorough understanding of the resources and problems facing resource management. A comprehensive description of these systems within the Reserve, a so-called "site profile," is an essential tool for this process.

The WBNERR Site Profile was begun by W. Malpass in 1992. It will be a comprehensive document summarizing the current knowledge of the Waquoit Bay ecosystem. It will include a bibliography to serve as a source of background material for researchers. Perhaps more important, it will identify gaps in our knowledge. The Site Profile is scheduled for completion by Fall 1993.

Waquoit Bay Estuary Water Quality Monitoring Project

An important component of the Phased Monitoring Program is the maintenance of a data base that records measurements of environmental variables. These data bases are intended to provide long-term records that reflect seasonal and annual changes and trends. The records are available to the

scientific community. In 1992, the WBNERR Water Quality Monitoring Project began monitoring water temperature, salinity, dissolved oxygen and compensation depth at several sites in Waquoit Bay. Sampling interval is roughly monthly in winter and bi-weekly during the rest of the year. The program will be expanded with a group of volunteer assistants in 1993.

Washburn Island Barrier Beach Breach Study

In August 1991, the storm surge and waves of Hurricane Bob eroded a portion of the barrier beach on Washburn Island and created a new inlet to the Waquoit Bay estuary (Fig. 8). This inlet is shallower than the other two inlets, which have been stabilized and dredged for navigational purposes. Area residents expressed concern that the new opening would be deleterious to the Waquoit Bay estuary. According to residents who were invited to contribute to the planning for the project, this change is most apparent in Eel Pond and in the Childs and Seapit rivers. They reported an apparent increase in tidal range and current velocity. There has also been increased sedimentation in the navigational channel which has affected boating.

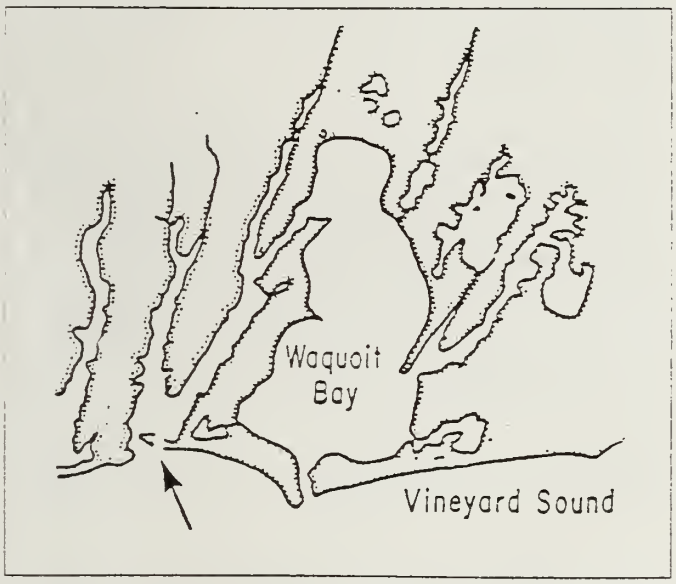

Figure 8. Location of the new inlet to the Waquoit Bay Estuary that was created by the storm surge of Hurricane Bob, 1991.

To respond to these concerns, the Washburn Island Barrier Beach Study was included in the WBNERR Monitoring Project. The project's objectives are to monitor the changes in the shape, dimensions, and movements of the breach and its associated barrier island and also to examine how the currents flowing through it affect adjacent waters in Eel Pond. Directed by the WBNERR Research Coordinator, Dr. R. Crawford, the project is being done in collaboration with the Falmouth High School Futures in Science (FIS) Program (T. Rowan) and the WHOI Sea Grant Program (Dr. G. Giese). The FIS program is monitoring sand deposition on the beach adjacent to the damaged area to further our understanding of sand transport dynamics in the area. Information from these studies will be provided to local agencies (e.g., Falmouth Waterways Commission and Massachusetts Coastal Zone Management) which are responsible for managing the use of coastal zone features and resources.

WBNERR Botanical Project

In 1992, the botanical survey of the WBNERR grounds was updated. Begun in 1988, this inventory revealed the occurrence of several rare plant species (Table 3). One of these (Sandplain Gerardia) is known in only seven locations in the world (two on Cape Cod).

Table 3. Rare native plant species found on WBNERR grounds. Status is that listed by the Massachusetts Natural Heritage Program.

Common name	Scientific name	Status
Sandplain Gerardia	*Agalinis acuta*	Endangered
Bushy Rockrose	*Helianthuemum dumosum*	Threatened
Butterfly-weed	*Asclepias tuberosa*	Watch List
Little Ladies' Tresses	*Spiranthes tuberosa*	Watch List
Eastern Lilaeopsis	*Lilaeopsis chinensis*	Watch List
NE Blazing Star	*Liatris borealis*	Watch List
Thread-Leaved Sundew	*Drosera filiformis*	Watch List
Vetchling	*Lathyrus palustris*	Watch List
Narrow-Leaved Wild Rice	*Zizania aquatica*	Watch List
Knotroot Foxtail	*Setaria geniculata*	Special Concern

The WBNERR Botanical Project coordinates the activities of volunteers who monitor the known locations of rare plant species on WBNERR territory to preserve their habitat and support their propagation. The project also maintains a seasonal mowing program to encourage the growth and propagation of species occurring on the grounds of the WBNERR Headquarters (the Swift Estate). Fields are mowed only in the early summer and late fall to permit flowering and seed dispersal. This project is done in

conjunction with the Massachusetts Natural Heritage Program (Massachusetts Division of Fisheries and Wildlife), established by The Nature Conservancy and the Commonwealth of Massachusetts.

WBNERR Endangered Bird Project

Two species of birds protected under the Endangered Species Act, the piping plover, *Charadrius melodus*, (Fig. 8) and the least tern, *Sterna antillarum*, nest on the WBNERR barrier beach (Dead Neck of South Cape Beach). A species listed as Threatened, the roseate tern, *Sterna dougalli*, forages in waters adjacent to the beach and rests on the beach proper. The greatest threats to the birds are unleashed dogs, wild predators (e.g., gulls, *Larus* spp.; common crows, *Corvus brachyrynchos*; red fox, *Vulpes vulpes*; and Eastern coyote, *Canis latrans*) and off-road vehicles. In addition to the obvious threats of disturbance and crushing, tire ruts in the sand may create traps for hatchlings. The WBNERR Endangered Bird Project, under the direction of volunteer F. LeBaron, constructs fencing and places warning signs around nesting areas. Volunteers also count birds, monitor nesting behavior, and record hatching and fledging success.

Data indicate these efforts have been successful as the numbers of these birds nesting here has increased in recent years. In 1992, piping plovers were reported on Washburn Island for the first time since 1984. The WBNERR Endangered Bird Project is done in conjunction with the Tern and Plover Project of the Massachusetts Natural Heritage Program (Massachusetts Division of Fisheries and Wildlife).

Inventory of Septic Systems in the Waquoit Bay Watershed

Despite increasing awareness of the impacts of septic system leachate on the Waquoit Bay ecosystem, our knowledge of the source of this pollution is limited. Consequently a WBNERR intern, M. Carey, is searching legal documents (e.g., building permits, septic tank pump-out records) to construct a data base on the number, type, age and location of septic systems in the watershed. These data will be used to evaluate management options in the use and application of innovative on-site wastewater treatment systems. The data will also improve modelling efforts examining the dynamics of nitrogen loading in Waquoit Bay.

Testing the Use of Waterfront Property Values for Hedonic Price Analysis

Coastal resource management would benefit from the development of an empirical assessment technique for evaluating the social impacts of a reduction in estuarine water quality. One such avenue uses resource economics methodology. Hedonic price technique is being explored to analyze aspects of Waquoit Bay waterfront property values. The long-term goal of this research is to establish a measure of the social worth of water quality, so that cost benefit analysis can be applied to strategies for maintaining or restoring water quality.

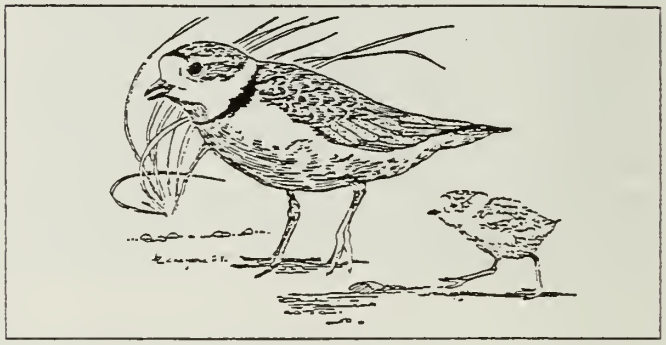

Figure 9. Piping Plover and chick.

Because this is an initial effort (3 month duration), the immediate objectives are: (1) to learn whether available data are adequate for hedonic price analysis; (2) if so, to test and estimate the contribution of water frontage to property values; and (3) to test and estimate the contribution of contiguous open space to waterfront property values. The project is being conducted by WBNERR intern, K. Blake, with the assistance of Dr. S. Edwards, a resource economist from the National Marine Fisheries Service.

WBNERR Waquoit Bay Estuary Boating Survey

During forums soliciting public opinion and interest regarding water pollution issues, popular concern was expressed about the potential negative impact of boat-discharged wastes on Waquoit Bay. The large size of the recreational boating fleet in the bay creates a strong visual perception that this recreational activity affects water quality. WBNERR designed a recreational boating survey to gather information to assess this perceived problem. Much of the survey work was done by interns, P. Thomas, C. Lamont and K. Blake. Results are being distributed to local towns to facilitate their management of the use of coastal water bodies.

Other Research Activities at Waquoit Bay

Fish Habitat Studies

Resource managers and civic associations are concerned with the effect of changing estuarine habitats on fisheries resources. For several years, NERRS has funded such studies by Dr. L. Deegan's group from the Ecosystems Center at MBL. She studies Waquoit Bay's eelgrass habitat, which has declined in size and been altered by an abundance of seaweed in recent years. In 1992, her group continued studies of fish and shellfish diversity, abundance, and mortality as well as eelgrass shoot density in beds with varying amounts of seaweed. Removing seaweed has resulted in increasing eelgrass shoot abundance, increasing fish abundance, and decreasing invertebrate diversity compared with sites where seaweed was added.

Night -Heron Feeding Ecology

A second research project at WBNERR concerned with the response of higher trophic levels to anthropogenic impacts is Dr. K. Parsons' work with black-crowned night-herons, *Nycticorax nycticorax*. Dr. Parsons, of the Manomet Bird Observatory, has found abdominal lesions on these birds that commonly feed in the Waquoit Bay watershed and adjacent areas. However, she has not detected similar lesions on black-crowned night-herons nesting in New York Harbor, which is much more polluted than Waquoit Bay. Nor have many lesions been found on Cape Cod snowy egrets (*Leucophoyx thula*) that nest where the affected night-herons do. Because the injured birds feed in Waquoit Bay and the unaffected birds do not, Dr. Parsons is investigating the hypothesis that the occurrence of lesions relates to the birds' foraging behavior. She has postulated that the causative agent may contaminate the birds' guano, which could, in turn, contaminate the nests and injure the nestlings.

Mute Swan Migration Behavior

Mute swans, *Cygnus olor*, which seasonally inhabit Sage Lot and Flat ponds are being studied in a project by M. Ciaranca and Dr. G. Jones at the Center for Vertebrate Study, Northeastern University. The mute swan is an introduced species which is expanding its range and displacing native waterfowl. Mute swan behavior is being investigated as it relates to the distribution of native waterfowl in southeastern Massachusetts. The project began in 1992 and will continue for three years.

The Physical Effects of Piers and Associated Vessel Use on Fishery Productivity

The impacts of piers on the littoral habitat in estuaries is poorly understood and little studied. Coastal resource managers who are mandated to consider the cumulative impact of structures in the coastal zone need information to determine if fisheries habitat and productivity are adversely affected by the construction, presence, or use of piers within a typical coastal Massachusetts estuarine system.

The project is to be conducted primarily by B. Barr of Massachusetts Coastal Zone Management, in collaboration with M. Hickey of the Division of Marine Fisheries, Massachusetts Department of Fish and Game, and WBNERR. Planning commenced in the summer of 1992. Field work is scheduled for the spring of 1993. The project has been initially funded for one year by NOAA's Office of Ocean and Coastal Resources Management.

EPA Environmental Monitoring and Assessment Program (EMAP)

The EPA, in cooperation with other federal agencies, is conducting the water body Environmental Monitoring and Assessment Program or EMAP. It is a nationwide interagency research, monitoring, and assessment program. Ecosystem health is assessed by examining the regional distribution of fish and bottom-dwelling organisms. EMAP is studying why some parts of estuaries support plants and animals and other parts do not. The program design covers large geographic areas. Although most station locations within these areas are random, Waquoit Bay was designated an EMAP study site in 1992. This selection was in recognition of the high quality of the research programs carried out by the Reserve and its associated programs.

Palmer Fellowship for Ecological Research

The Palmer family, who lives on the shore of Waquoit Bay, has endowed a fellowship at Boston University for the support of graduate studies in ecological research of Waquoit Bay. The fellowship is administered through the Boston University Marine Program. The 1992 award went to M. LaMontagne. His research concerned the phenomenon of denitrification at the interface between the waters of Waquoit Bay and its sediments.

Advanced Technologies for Wastewater Treatment

On February 27-28, 1992, WBNERR sponsored a conference called Nitrogen Removal Onsite Wastewater Treatment Systems: Technologies and Regulatory Strategies. Coordinated by the former WBNERR Research Translator, N. Gurwick, and Reserve Manager, C. Gault, the goal was to provide Massachusetts regulators and citizens with information about advanced onsite wastewater treatment technologies and regulatory strategies. The primary contributions were made by specialists from other states where these technologies are more widely used. A secondary goal was to foster interaction, education, and cooperation among the various state agencies represented.

The conference was attended by more than 250 people from as far away as California, Florida, and Texas. They represented many levels of government, professional engineering and consulting firms, concerned residents, non-profit organizations, and civic associations. WBNERR published and distributed a Position Paper from the conference in the Fall of 1992. Interest sparked by the event resulted in the formation in June 1992 of a committee of representatives from Massachusetts state, county, and town governments who meet monthly to discuss advanced technology wastewater treatment issues.

Because of its leadership on this issue, WBNERR was chosen in October 1992 as one of eight "communities" in the United States to participate in a National Small Flows Clearing House program to study the efficacy of new advanced wastewater treatment processes. Other communities in the program are Gloucester, Massachusetts; Anne Arundel and Dorchester counties, Maryland; Paradise and Presidio, California; Monongalia County, West Virginia; and Benzie County, Michigan. Waquoit Bay Reserve, with a grant totalling $200,000, is the only participant representing NEERS.

A committee comprised of representatives from various local and regional government bodies, as well as members of the local scientific community has been struck to oversee the Waquoit Bay Advanced Wastewater Treatment Technology Demonstration Project. This project is coordinated by C. Gault, WBNERR Manager. Plans call for commencing field testing several technologies late in 1993.

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